

**WHAT IS CLAIMED IS:**

1. A vehicular motion control apparatus,  
comprising:

5 a steering angle detecting section that detects  
a vehicular steering angle;

a vehicle speed detecting section that detects  
a vehicle speed;

a vehicular motion control mechanism that is  
10 capable of controlling a vehicular motion;

a state detecting section that detects a state  
of the vehicular motion control mechanism;

a vehicular motion target value calculating  
section that calculates a target value of the  
15 vehicular motion for a response characteristic on a  
vehicular plane motion to be enabled to provide a  
predetermined response characteristic on the basis of  
detection values of the steering angle and the  
vehicle speed and vehicle speed dependent constants  
20 preset in a form of a map for each vehicle speed;

a control command value calculating section  
that calculates a vehicular motion control mechanism  
command value required to achieve the target value of  
the vehicular motion; and

25 a servo calculating section that provides a  
control signal for a rear road wheel steering  
actuator in such a manner that a detection value of  
the state of the vehicular motion control mechanism  
is made coincident with the motion control mechanism  
30 command value; and

a vehicular velocity variation rate limiter  
that places a limitation on a vehicle speed variation  
rate and varies in accordance with the detection

value of the vehicular steering angle, the vehicular motion target value calculating section using an output of the vehicular speed variation rate limiter for a map reference vehicle speed and the control  
5 command value calculating section using the output of the vehicular speed variation rate limiter to the detection value of the vehicle speed for a control command value calculation.

10 2. A vehicular motion control apparatus as claimed in claim 1, wherein the vehicle speed variation rate limiter is designed in such a manner that, as the detection value of the steering angle becomes larger, a limit value of the vehicle speed variation rate is  
15 made smaller and, as the detection value of the steering angle becomes smaller, the limit value of the vehicle speed variation rate is made larger.

3. A vehicular motion control apparatus as claimed  
20 in claim 1, wherein the vehicular motion control mechanism comprises a rear road wheel steering angle providing section that provides a rear road wheel steering angle for the vehicle, the state detecting section comprises a rear road wheel steering angle  
25 detecting section that detects the rear road wheel steering angle, the control command value calculating section comprises a rear road wheel steering angular command value calculating section that calculates a rear road wheel steering angle command value required  
30 to achieve the vehicular motion target value, and the rear road wheel steering angle command value calculating section approaches the rear steering angle command value to zero when the detection value

of the vehicle speed is lower than a preset vehicle speed irrespective of a result of calculation of the rear road wheel command value required to achieve the vehicular motion target value.

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4. A vehicular motion control apparatus as claimed in claim 3, wherein the vehicular motion value calculating section comprises a vehicular motion target value setting section that calculates a target yaw rate ( $\Psi'^*$ ) and a target yaw angular acceleration ( $\Psi''^*$ ) on the basis of the detection values of a front road wheel steering angle detecting section and of the vehicle speed detecting section, the rear road wheel steering command value calculating section calculates a target rear road wheel steering angle ( $\delta^*$ ) on the basis of the target yaw rate ( $\Psi'^*$ ), target yaw angular acceleration ( $\Psi''^*$ ), the detection values of the front road wheel steering angle ( $\theta$ ) and the vehicle speed ( $V$ ), and the servo calculating section comprises a rear road wheel steering angle servo calculating section that outputs the control signal to the rear road wheel steering actuator in such a manner that the rear road wheel steering angle ( $\delta$ ) detected by the rear road wheel steering angle detecting section is made coincident with the target value of the rear road wheel steering angle ( $\delta^*$ ).

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5. A vehicular motion control apparatus as claimed in claim 4, wherein the vehicular motion target value setting section calculates the target yaw rate ( $\Psi'^*$ ) to the front road wheel steering angle ( $\theta$ ) on the basis of a predetermined transfer function ( $\Psi'^*/\theta$ )

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between the front road wheel steering angle ( $\theta$ ) and the target yaw rate ( $\Psi'^*$ ), the predetermined transfer function having a plurality of vehicle speed dependent constants which are preset to enable their predetermined characteristics in accordance with the vehicle speed which is the map reference vehicle speed ( $V_{map}$ ) and the vehicle speed for the control command calculation.

6. A vehicular motion control apparatus as claimed in claim 5, wherein the rear road wheel steering angle command value calculating section calculates the target rear road wheel steering angle ( $\delta^*$ ) which enables an actual yaw rate to be coincident with the target yaw rate ( $\Psi'^*$ ) on the basis of the target yaw rate ( $\Psi'^*$ ), the target yaw angular acceleration ( $\Psi''^*$ ), the detection value of the front road wheel steering angle ( $\theta$ ), and the detection value of the vehicle speed which is the map reference vehicle speed ( $V_{map}$ ) through the vehicle speed variation rate limiter.

7. A vehicular motion control apparatus as claimed in claim 6, wherein the vehicle speed variation rate limiter comprises: a vehicle speed variation rate limit value setting section that sets a vehicle speed variation rate limit value ( $dV_{limit}$ ) in accordance with an absolute value of the steering angle ( $|\theta|$ ) detected by the front road wheel steering angle detecting section; a first map reference vehicle speed comparing section that compares the present detection value ( $V$ ) of the vehicle speed with a

previous map reference vehicle speed ( $V_{map}(n-1)$ ) before a predetermined control period to determine whether the present detection value of the vehicle speed ( $V(n)$ ) is equal to, larger than, or smaller than the previous map reference vehicle speed ( $V_{map}(n-1)$ ); a second map reference value comparing section that compares a first difference of the present value of the vehicle speed ( $V(n)$ ) from the previous map reference vehicle speed ( $V(n) - V_{map}(n-1)$ ) is larger than the vehicle speed variation limit value ( $dV_{limit}$ ) when the first map reference vehicle speed comparing section determines that the present detection value of the vehicle speed ( $V(n)$ ) is higher than the previous map reference value ( $V_{map}(n-1)$ ); a third map reference vehicle speed comparing section that compares a second difference of the previous map reference value ( $V_{map}(n-1)$ ) from the present detection value of the vehicle speed ( $V_{map}(n-1) - V(n)$ ) with the vehicle speed variation rate limit value ( $dV_{limit}$ ) to determine whether a difference ( $V(n) - V_{map}(n-1)$ ) of the present detection value of the vehicle speed ( $V(n)$ ) from the previous map reference vehicle speed ( $V_{map}(n-1)$ ) is larger than the vehicle speed variation rate limit value ( $dV_{limit}$ ) when the first map reference vehicle speed comparing section determines that the present value of the vehicle speed ( $V(n)$ ) is smaller than the previous value of the map reference vehicle speed ( $V_{map}(n-1)$ ); a first map reference vehicle speed setting section that sets the present map reference vehicle speed ( $V_{map}(n)$ ) in such a manner that the present map reference vehicle speed is set to be equal to an addition of the previous detection value of the map reference vehicle

reference vehicle speed to the vehicle speed  
variation rate limit value ( $dVlimit$ ) ( $Vmap(n) =$   
 $Vmap(n-1) + dVlimit$ ) when the second map reference  
vehicle speed comparing section determines that the  
5 difference of the present value of the detection  
value of the vehicle speed ( $V(n)$ ) from the previous  
map reference vehicle speed ( $Vmap(n-1)$ ) is larger  
than the vehicle speed variation rate limit value  
( $dVlimit$ ); a second map reference vehicle speed  
10 setting section that sets the present value of the  
map reference vehicle speed ( $Vmap(n)$ ) is set to be  
equal to the present detection value of the vehicle  
speed ( $V(n)$ ) when the first map reference vehicle  
speed comparing section determines that the present  
15 value of the detection value of the vehicle speed  
 $V(n)$  is equal to the previous map reference vehicle  
speed ( $Vmap(n-1)$ ), when the second map reference  
vehicle speed comparing section determines that the  
first difference ( $(V(n) - Vmap(n-1))$ ) is equal to or  
20 smaller than the vehicle speed variation rate  
limitation value ( $dVlimit$ ), and when the third map  
reference vehicle speed comparing section determines  
that the second difference is equal to or smaller  
than the vehicle speed variation rate limit value  
25 ( $dVlimit$ ); and a third map reference vehicle speed  
setting section that sets the present value of the  
map reference vehicle speed ( $Vmap(n)$ ) is equal to a  
subtraction of the previous value of the map  
reference vehicle speed ( $Vmap(n-1)$ ) from the vehicle  
30 speed variation rate limit value ( $dVlimit$ ) when the  
third map reference vehicle speed comparing section  
determines that the first difference ( $V(n) - Vmap(n-$

1)) is larger than the vehicle speed variation rate limit value ( $dV_{limit}$ ).

8. A vehicular motion control apparatus as claimed  
5 in claim 7, wherein the vehicle speed dependent constants ( $G\Psi'$ ,  $\omega_n$ ,  $\zeta$ ,  $n_1$ ) are determined in accordance with the present value of the map reference vehicle speed ( $V_{map}(n)$ ) set by any one of the first, second, and third map reference setting  
10 sections.

9. A vehicular motion control apparatus as claimed  
in claim 6, wherein the rear road wheel steering  
angle command value calculating section comprises: a  
15 vehicle speed region determining section that determines whether the detection value of the vehicle speed is lower than a predetermined vehicle speed ( $B$ ); a first rear road wheel steering angle command value comparing section that compares an absolute  
20 value of a previous value of the rear road wheel steering angle command value ( $|\delta^{*}(n-1)|$ ) before a predetermined control period with a rear road wheel steering angle command value convergence quantity ( $\alpha$ ) to determine whether the absolute value of the  
25 previous value of the rear road wheel steering angle command value ( $|\delta^{*}(n-1)|$ ) is larger than the rear road wheel steering angle command value convergence quantity ( $\alpha$ ) when the detection value of the vehicle speed ( $V$ ) is lower than the predetermined vehicle  
30 speed ( $B$ ); a first rear road wheel steering angle command value setting section that sets the present value of the rear road wheel steering angle command value  $\delta^{*}(n)$  to zero when the absolute value of the

previous value of the rear road wheel steering angle  
command value ( $|\delta^{*(n-1)}|$ ) is equal to or lower than  
the rear road wheel steering angle command value  
convergence quantity ( $\alpha$ ) ( $|\delta^{*(n-1)}| \leq \alpha$ ); a second  
5 rear road wheel steering angle command value  
comparing section that compares the previous value of  
the rear road wheel steering angle command value  
( $\delta^{*(n-1)}$ ) with zero when the absolute value of the  
previous value of the rear road wheel steering angle  
10 command value ( $|\delta^{*(n-1)}|$ ) is larger than the rear  
road wheel steering angle command value convergence  
quantity ( $\alpha$ ) ( $|\delta^{*(n-1)}| > \alpha$ ); a first rear road  
wheel steering angle command value setting section  
that sets the present value of the rear road wheel  
15 steering angle command value  $\delta^{*(n)}$  to zero when the  
absolute value of the previous value of the rear road  
wheel steering angle command value ( $|\delta^{*(n-1)}|$ ) is  
equal to or smaller than the rear road wheel steering  
angle command value convergence quantity ( $\alpha$ ); a  
20 second rear road wheel steering angle command value  
setting section that sets the present value of the  
rear road wheel steering angle command value  $\delta^{*(n)}$  as  
follows:  $\delta^{*(n)} = \delta^{*(n-1)} - \alpha$ , when the previous value  
of the rear road wheel steering angle command value  
25  $\delta^{*(n-1)}$  is larger than zero; and a third rear road  
wheel steering angle command value setting section  
that sets the present value of the rear road wheel  
steering angle command value  $\delta^{*(n)}$  as follows:  $\delta^{*(n)}$   
=  $\delta^{*(n-1)} + \alpha$ , when the previous value of the rear  
30 road wheel steering angle command value  $\delta^{*(n-1)}$  is  
equal to or smaller than zero.



10. A vehicular motion control apparatus as claimed in claim 9, wherein the rear road wheel steering command value convergence quantity ( $\alpha$ ) is a set value of a speed at which the absolute value of the rear road wheel steering angle command value  $|\delta^*(n)|$  is approached to zero.

11. A vehicular motion control apparatus, comprising:

steering angle detecting means for detecting a vehicular steering angle;

vehicle speed detecting means for detecting a vehicle speed;

vehicular motion controlling means which is capable of controlling a vehicular motion;

state detecting means for detecting a state of the vehicular motion controlling means;

vehicular target value calculating means for calculating a target value of the vehicular motion for a response characteristic on a vehicular plane motion to be enabled to provide a predetermined response characteristic on the basis of detection values of the steering angle and the vehicle speed and vehicle speed dependent constants preset in a form of a map for each vehicle speed;

control command value calculating means for calculating a vehicular motion controlling means command value required to achieve the target value of the vehicular motion; and

servo calculating means for providing a control signal for a rear road wheel steering actuator in such a manner that a detection value of the state of the vehicular motion controlling means is made

coincident with the motion control mechanism command value; and

vehicular velocity variation rate limiting means for placing a limitation on a vehicle speed variation rate and varies in accordance with the  
5 detection value of the vehicular steering angle, the vehicular motion target value calculating means using an output of the vehicular speed variation rate limiting means for a map reference vehicle speed and  
10 the control command value calculating means using the output of the vehicular speed variation rate limiting means to the detection value of the vehicle speed for a control command value calculation.

15 12. A vehicular motion control method, comprising:  
detecting a vehicular steering angle;  
detecting a vehicle speed;  
providing a vehicular motion control mechanism which is capable of controlling a vehicular motion;  
20 detecting a state of the vehicular motion control mechanism;  
calculating a target value of the vehicular motion for a response characteristic on a vehicular plane motion to be enabled to provide a predetermined  
25 response characteristic on the basis of detection values of the steering angle and the vehicle speed and vehicle speed dependent constants preset in a form of a map for each vehicle speed;  
calculating a vehicular motion control  
30 mechanism command value required to achieve the target value of the vehicular motion; and  
providing a control signal for a rear road wheel steering actuator in such a manner that a

detection value of the state of the vehicular motion control mechanism is made coincident with the motion control mechanism command value; and

providing a vehicle speed variation rate  
5 limiter to place a vehicle speed variation rate limitation on the detection value of the vehicle speed and varying the vehicle speed variation rate limitation in accordance with the detection value of the vehicular steering angle, at the vehicular motion  
10 target value calculation, using an output of the vehicular speed variation rate limiter for a map reference vehicle speed and, at the control command value calculation, using the output of the vehicular speed variation rate limiter to the detection value  
15 of the vehicle speed for a control command value calculation.

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